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DAMSITE RECONNAISSANCE

of the

LOWER MEKONG BASIN

by
Allen H. Nicol

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Introduction

Four damsites on the main stem of the Mekong River and two sites on tributaries in northeast Thailand were visited in the field during the period of October 19 to 28, 1964. The main stem sites include the Upper and Lower Pakse, Khemarat and Thakhek; the tributary sites are the Nam Mune and Huey Bang Sai. A third tributary site, Nam San, could not be reached due to landslides on the road leading to the site. The writer was accompanied in the field by Mr. Lance Endersbee of the UNTAO, Mr. S. Ichiura of ECAFE, and engineers of the National Energy Authority, Government of Thailand.

During the period of this investigation the Mekong River and tributaries were in high flood stage. Observations were therefore severely restricted and limited entirely to the upper parts of the banks and abutments. Geophysical traverses were made along both banks of the Nam Mune site by Mr. Somchat Suathongcum of the National Energy Authority to determine overburden thickness. A photogeology study made by the writer prior to the field inspection supplied much useful data to supplement this report.

/ General

General Geology

The northeast part of the Khorat Plateau in which the sites are located is underlain by Triassic sedimentary rocks of the Khorat Series. They consist mainly of sandstone, siltstone, shale, mudstone, conglomerate and limestone. Five of the sites are in the Khorat Series but the Thakhek site, according to the published geologic map, is in Jurassic and younger sedimentary rocks consisting mainly of sandstone and shale.

The Khorat Plateau is a fairly stable land-mass which has been little affected by orogenic movement. Major faults, severe folding or other structural deformation is consequently not very common except along the margin of the plateau. Very gentle folding was found at the sites and in most cases the beds have a very low angle to nearly horizontal dip.

The sedimentary beds comprising the Khorat Series form a complex sequence ranging from durable, firm types of quartzose sandstones to soft, friable sandstones and weak shales. The various types show marked differences in their resistance to erosion and weathering and therefore they can be expected to have a wide range in their engineering characteristics. A brief description of these characteristics together with pertinent geologic features is given separately for each of the sites.

Nam Mune Damsite

This site is located approximately 600 meters downstream of a small island and rapids, and approximately 3000 meters from the confluence of the Nam Mune with the Mekong River. A tentative axis has been located, benchmarks have been set, and a topographic map and cross section compiled by the National Energy Authority. During the time of this inspection the high stage of the Nam Mune prevented observation of the lower parts of the abutments and therefore the data presented here are applicable only to the portion above water level.

Left Bank Geological Conditions

Brown river silt covers much of the left bank above water level (October 21, 1964) to approximately 101 meters, elevation, above which the slope steepens and is strewn with large sandstone talus blocks up to several meters in size. Sandstone bedrock crops out still further up slope and caps

/the flat

the flat upper part of the abutment. This rock is coarse-grained, part conglomeratic, with a northerly strike and a gentle to nearly horizontal westerly dip. Two sets of widely spaced joints were found, one set striking nearly parallel with the axis and the other perpendicular; these joints appear to be fairly tight at the surface. The sandstone beds range from less than a half meter to one meter or more in thickness and some show cross-bedding. The surface beds at the top of the slope are mainly massive, hard and firm but some interbeds are friable and weakly cemented. High seismic velocities were obtained by the geophysical investigation which indicate the presence of firm rock, with about 6 meters of overburden. It must be pointed out, however, that due to the limitations of the method and equipment used, the underlying interbeds (if present) of softer and weaker types such as clay shale, crumbly shale and sandstone or clay lenses cannot be detected due to their slower seismic velocities. The prominent slumping and downward creep of the large sandstone blocks along the abutment slope suggests that some firm beds have been undermined and detached by breakage along joints.

Occasional gray clay or shale beds were seen in the hill north of the village of Bon Pak but none were found in the general site area, nor along the axis of the dam. There is however, in my opinion, a strong possibility of clay or soft shale interbeds or intercalations within the foundation beds at the Nam Mune site. Some of these soft beds might have a thickness of one meter or more, but most would probably be less. Their possible occurrence at unexpected depths will require very careful drilling to avoid loss of core. Although practically impermeable, they will have doubtful stability for foundation support and may easily erode. Their position and thickness in the sequence of underlying foundation beds will need to be determined by borings.

Right Bank Geological Conditions

The right bank is covered by brown river silt with a high level terrace at approximately 100 meters elevation. A geophysical traverse along this terrace perpendicular to the axis indicates about seven meters of alluvial river silt and sand, which is comparable with overburden thickness found at the left bank. Average seismic velocities for the bedrock are much lower in the

/downstream

downstream direction from the axis than in an upstream direction. They are also lower than the velocities at the left bank. This suggests beds of weaker character underlie the downstream portion of the right bank. A distinct cliff line near the benchmark exposes fairly firm sandstone which compares favorably with the firm rock at the top of the left abutment.

Engineering Considerations

The favorable, although gentle upstream dip would tend to minimize the possibility of leakage along bedding planes. However, the east-west joints might be a source of leakage under the dam and might require grouting or other treatment.

There is no evidence in the field nor from the aerial phtotgraphs of old meanders of the Nam Mune or the nearby Mekong River, or of channel changes that might affect the damsite.

Slumping of large sandstone blocks along the left abutment suggests undermining by weaker beds. This situation, as previously pointed out, is one which calls for careful subsurface investigation.

The exposed bedrock in the upper part of both abutments is of sufficient strength to require blasting for effective excavation. Although some weakly cemented beds occur, the general conditions will call for rock excavation rather than earth excavation.

Overburden stripping of 6 to 7 meters, maily river silt and fine sand, is indicated. In the lower portions along the barks the overburden may reach 10 meters or more.

The engineering suitability of the firmer sandstone beds as crushed aggregate for concrete is difficult to evaluate visually and will require sampling and testing. Since sandstone is the prevailing rock of the area it should be possible by careful prospecting to locate a suitable quarry site.

Although the aerial photographs show sand and gravel bars in the Nam Mune and the Mekong Rivers, the high stage of both prevented their observation. Exploration in this regard is essential during low water.

In the event river diversion by tunnel method is adopted during construction, the left bank appears to offer a favorable alignment. The

/tunnel line

tunnel line will be nearly perpendicular to the strike of the gently dipping beds of dissimilar character, some of which will require support.

With a proposed H.L of 110 meters the impounded water will reach upstream as far as Ubol. The effect this may have upon the water table in the surrounding area beyond the reservoir limits is uncertain but some local raising can be expected where submerged beds of permeable rock reach the surface and can develop permanent ponding in the depressions.

Conslusions

The Nam Mune Damsite is underlain by sedimentary beds of the Korat Series consisting mainly of sandstones of dissimilar properties with a possibility of some thin clay, clay-shale or other weak interbeds.

The surface geological conditions appear to be fairly satisfactory for the construction of a concrete gravity dam at this site, but subsurface exploration by borings will be required to understand the foundation conditions in detail.

Some of the sandstone beds appear suitable for aggregate and riprap but others are friable and doubtfully suitable. Sand and gravel deposits for concrete aggregates could not be examined on account of high water but this should be undertaken during the low water period.

Since a concrete dam is envisaged at this site, the requirements for a side-channel spillway were not investigated.

Recommendations

In the event the Nam Mune Damsite is considered feasible from economic and other aspects, the following recommendations are presented as the first stage of a geological exploration program.

1. A detailed geological map should be prepared of the site area at approximately 1:2000 scale.

2. Geophysical investigations should be made during the low water period with traverses oriented perpendicular to the axis at different elevations to determine overburden thickness and bedrock conditions. This work can be done concurrently with the boring program, or after a few borings have been completed. It would also be helpful to make geophysical studies of

/the in-place

the in-place bedrock at the upper part of both abutments in order to better understand and correlate the seismic data with the borings.

3. Six borings are recommended in the initial stage. At each bank one vertical boring is recommended along the axis near crest elevation and one vertical boring midway downslope, making a total of four borings. Each of these vertical borings should be deep enough to provide a slight overlap in elevation between them to enable extrapolation equivalent to one continuous boring. The other two borings, one at each bank, should be inclined. They should be located near river level (to overlap slightly the bottom of the midpoint borings) and should be drilled deep enough and at such an angle that they will intersect each other under the channel of the river. In the event inclined borings are not possible, it will be necessary to erect a platform for drilling underwater in the main channel section of the river. All borings should be not less than size NX and should be pressure-tested. The utmost care should be used in order to obtain high core recovery.

4. The construction materials situation requires careful study. A survey should be made of sand and gravel bars in the vicinity of the site. In the event the volume is inadequate and the quality or gradation of the river aggregates is unsatisfactory for concrete it will be necessary to prospect for a quarry site to supply suitable crushed rock.

PAKSE DAMSITE AREA

Downstream Site Area

The area described here is located approximately midway between the confluence with the Nam Mune River and the boundary between Thailand and Laos, on the Mekong River, or approximately 3.2 kilometers upstream from the Laos boundary. The tentative site which was originally proposed to visit is located further downstream in Laos and was not inspected due to prevailing security regulations.

At the point where this description applies, the channel of the Mekong is quite narrow, being 250 meters or less, and is unquestionably very deep. Bedrock of the Khorat Series is well exposed along both banks. At the right

/bank

bank the bedrock is a medium-grained light yellow sandstone occurring in beds ranging from a half meter to two meters in thickness. The rock is quite firm, although some friable beds occur. Joints are narrow, tight and irregular in spacing; they trend more or less parallel to the axis, with minor joints perpendicular to the axis. The beds strike north and dip a few degrees west which gives them a slightly oblique but favorable upstream dip. There is no mud bank at the river line (October 21, 1964) and no evidence of terrace development.

At the left bank (Laos side) the beds appear somewhat thinner but of the same general character as those on the right bank, but no landing was made. Observation of the left bank was made by binoculars from the Thailand side of the river.

The foundation conditions for the construction of a concrete gravity dam should be good along this stretch of the Mekong, provided sandstone beds extend below water level. As previously pointed out, the Khorat Series consists mainly of sandstone but contains interbeds of soft, friable materials and clay. Although no evidence of soft interbeds was seen at the time of this visit, the possibility remains of their occurrence in the lower part of the sequence, and requires further study.

The aggregate situation will require detailed investigation. Due to high water no observation could be made of possible bars along the Mekong. The aerial photographs show very few bars in this area, however, but several occur some distance upstream in the visinity of the upstream site. The photographs also indicate an abundance of outcrops, probably sandstone, on both the Laos and Thailand sides of the river. On the Laos side a series of steep-sided, step-like benches occur, probably formed by differential erosion of soft and firm beds. By prospecting in this area it should not be difficult to locate a quarry site to produce crushed rock for coarse concrete aggregate but fine aggregate might be more of a problem.

There is a possibility that the channel of the Mekong here is too narrow to provide an overflow spillway of adequate size for the Mekong River at peak flood. However, the river widens both upstream and downstream so a

/more suitable

more suitable site could be tentatively selected. The geological conditions a short distance upstream or downstream should be generally similar to those which have been described.

Conclusions

The geological conditions in the upper part of the abutments appear favorable for the construction of a concrete gravity dam. Assuming rock of this character to extend down the abutment slopes (below presnet high water, October 21, 1964) and to underlie the channel, there would be no question about foundation stability. Some soft interbeds are likely to occur in the deeper foundation sections, however, and these can only be discovered by borings.

A tentative axis at this location is objectionable since the channel appears too narrow to provide adequate spillway capacity. Wider channel conditions prevail a short distance upstream and downstream from this location, however, where an axis of suitable width could be found, and where the geological conditions should be similar to those which have been described.

Gravel and sand for aggregates may not be locally available in the immediate vicinity but a quarry could be easily prospected and developed to produce crushed rock.

Recommendations

In the event this lower site is preferred to the upper Pakse site, a tentative axis location should be made where channel width and topographic conditions are favorable.

The lower Pakse site area should be revisited during the low water stage of the Mekong to observe the geological conditions and rock characteristics in the lower abutment slopes and the channel section, which could not be done during this trip.

Geologic mapping should be made in the site area prior to subsurface exploration in order to provide a basis for the preliminary boring program.

A construction materials survey should be made either concurrently with the geologic mapping or following it in order to evaluate the sand and

/gravel bars

gravel bars and potential quarry sites.

Upstream Site Area

The upstream Pakse damsite area described here is located approximately 6.5 kilometers upstream from the confluence of the Nam Mune River, or approximately 1.5 kilometers upstream from the confluence of the Huai Yang and the Mekong. Here the river flows in a narrow channel with bedrock exposed along both banks. The sedimentary beds belong to the Khorat Series and consist of nearly flat-lying sandstones and pebbly conglomerates. There is no apparent indication of folding, faulting or other structural deformation. The regional attitude, based on aerial photos, is a northerly strike and a very gentle westerly dip of a few degrees. The major joint system trends parallel with the stream flow, or northeast. Minor joints trend northwest, or approximately parallel with the axis. The joints are widely but irregularly spaced and fairly tight at the surface. Individual sandstone beds range from less than 1 meter to 2 meters or more in thickness.

Any number of tentative sites for a low dam could be located in this area where the geological conditions should be very nearly the same as those described but with greater channel width to provide adequate spillway capacity.

The foundation conditions should be very good in rock of this kind provided similar types occur lower in the sequence. Occasional beds are weakly cemented and friable, and the condition of the underlying beds in the channel area cannot be determined without borings. The Khorat Series contains a variety of soft interbeds which may be present in this area but could not be observed during high water. Based on the condition of the rock in the upper beds, blasting will be required for expeditious removal.

As construction material, some beds are probably unsatisfactory for aggregate or riprap on account of their friability. Other firmer beds might be entirely suitable for aggregate after crushing and processing. A quarry site to produce suitable crushed rock for coarse aggregate for concrete should be possible to locate through field exploration on either the Laos or the Thailand side. Evaluation of quality or durability, however, would require sampling and engineering testing. It would also be advisable to investigate the

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suitability of the finer crushed fractions for fine aggregate in the event an adequate supply of suitable river sand may not be readily available in the site area.

Conclusions

The geological conditions appear favorable for the construction of a concrete gravity dam in this area. This opinion is based on the assumption that the general character of the upper abutment rocks extend with depth and underlie the lower slopes and channel. A valid understanding of the rock conditions lower down in the sequence can only be obtained by subsurface investigation.

As is the case with the lower Pakse site, any number of tentative axes can be located within one or two kilometers upstream or downstream from the area which is described above, and where wider channel conditions prevail and the geological conditions should be similar.

A quarry could be easily located to produce crushed rock for construction purposes but availability of sand and gravel for aggregates will require investigation during low water.

Recommendations

In view of the similarities in geological conditions of the upper and lower Pakse site areas, the recommendations made for the lower site apply equally well to the upper Pakse site. Briefly, they include a revisit during low water, selection of a tentative axis, detailed geologic mapping and a construction materials survey.

KHEMARAT DAMSITE AREA

The Khemarat Damsite area is located approximately 25 kilometers downstream from Khemarat village, in the downstream part of a sharp bend of the Mekong River. The area described here is located on a rock spur in a narrow gorge, on the right bank (Thailand side.) It was visited on October 23, 1964 by boat during extreme high water. This location is approximately midway between the upper and lower tentative axes.

Triassic sedimentary beds of the Khorat Series are well exposed in the

/area. The

area. They consist mainly of medium to coarse-grained sandstones that strike northwest and dip northeast from 5 to 10 degrees. Individual beds range from less than one half meter to over one meter in thickness but most are less than one meter. Most of the sandstone beds appear fairly firm but occasional beds are weakly cemented and can be crumbled by hand. Surface beds in the upper part of the abutment may be more weathered than the underlying beds but high water prevented observation. Considerable slumping of these upper beds suggests undermining of weaker layers but no direct evidence was seen as to the character of the weaker interbeds. It is possible that lower in the sequence there may be soft shale or clay-shale interbeds or lenses but this possibility is not confirmed on account of high water. The major joints in this particular area are widely spaced, up to several meters apart, and trend northerly. Some are open and gaping at the surface, but they appear to close with depth. Potholing is extensively developed in some beds, and a black surface tarnish or glaze due to algae is common.

Location of a site in this area along the Mekong will be influenced by the prevailing northwest strike and northeast dip of the beds with respect to the course of the Mekong. Where the river flows parallel to the strike of the beds the axis of any dam will cross a series of beds having dissimilar engineering properties and there is a strong possibility that the bearing capacities of the foundation beds will vary greatly from bed to bed. This condition will create difficulties in the design of a concrete dam. There is furthermore the possibility of leakage along bedding planes. But in those reaches where the river flows more or less from north to south, the beds strike across the river, parallel with any tentative axis, and have a favorable upstream dip. This orientation is preferred in that fewer problems will be encountered in design and possible leakage will be minimized.

Faulting may occur near the downstream axis, on the right bank (Thailand side) in the vicinity of the falls, based on the air photographs. Two or three faults may occur there, and one of them may cross the Mekong below the falls. There was insufficient time to confirm their presence on the ground, but this can be done in the normal course of geologic mapping at a later date.

/Slickensides

Slickensides were found parallel to bedding planes in several places along the spur, but these may have formed by bedding plane glide during gentle regional folding. Otherwise no evidence of intense folding, severe fracturing or other structural disturbances were found. The left bank (Laos side) was not visited.

Based on the character of the upper beds, it is possible that some could supply aggregate or riprap. However, many beds appear too friable for aggregate. Prospecting of the area should be done to locate a suitable quarry site.

Foundation support should be adequate in the sandstone beds but the possibility of soft interbeds lower in the sequence and underlying the channel will require investigation by borings.

Conclusions

There is a possibility that sandstone beds of dissimilar properties with soft interbeds of an easily eroded or compressible type occur in the Khorat Series of the area.

A preferred axis location therefore is one which is parallel with the strike and the beds have an upstream dip.

This preferred orientation will be found in the nearby reaches of the Mekong which flow from north to south.

Feasibility of the site area for a concrete gravity dam will depend very largely on foundation conditions in the underlying strata which cannot at present be surmised, without subsurface investigation. Much additional information could be obtained, however, by revisiting the Khemarat Damsite Area during the low water period.

Recommendations

The Khemarat damsite area should be revisited during the low water period to observe the character of the underlying strata that should be exposed along the banks and in the channel. Two or more tentative axes could be arbitrarily selected at that time.

It is recommended that a tentative axis be located along the north-south stretches of the Mekong in order to provide a more favorable orientation of the strata for the dam foundation.

/after

After selection of a feasible axis location, detailed geologic mapping and a construction materials survey should be made. This work should precede any subsurface exploration in order to provide a basis for a preliminary boring program.

Since soft interbeds may be present in the underlying strata it is recommended that the utmost care be given during boring operations to assure high core recovery.

HUAY BANG SAI DAMSITE

This site is located approximately 23 kilometers northwest of Mukdahan in northeast Thailand on the Huay Bang Sai River, a tributary of the Mekong. It was visited on October 25, 1964.

The area is underlain by sedimentary beds of the Khorat Series consisting mainly of sandstone and some sandy shale, with occasional soft, weakly cemented interbeds. In the vicinity of the site a firm, fine-grained, gray sandstone is exposed along the left bank. These beds strike northwest and dip about 3° northeast. Firm beds cap the knobs of the low hills along the left bank and comprise most of the upper part of the left abutment. The right bank is covered by brown river silt and sand, with no outcrops. No evidence was found of faulting, folding or other structural disturbance.

Individual beds range from a few centimeters to about one-half meter in thickness. Two prominent sets of vertical joints occur. One set strikes northeast-southwest and the other set is perpendicular, striking northwest-southeast; less prominent oblique joints strike east-west. Jointing is widely spaced. The well developed jointing in the area is very likely responsible for the zigzag course of the stream. The channel here is not deeply incised by the young stream and is quite narrow.

Foundation conditions at this site should be satisfactory for a rock fill or a concrete dam, but this will have to be determined by field investigation and exploratory borings. It is very likely that some weaker interbeds may underlie the firmer sandstones but their thickness, bearing capacity and permeability need investigation. The prominent jointing conditions indicate

/some grouting

some grouting may be required if the joints extend very deep into the dam foundation. The axis of the dam has an approximate azimuth of north 30° east and will therefore cut obliquely across the dip of the foundation beds at a very small angle. Since the beds have a gentle downstream dip, it is possible that if permeable sandstones occur in the lower part of the foundation beds they will require adequate cut-off and grouting to minimize leakage.

Sand and gravel bars are not prominently developed along the stream; the availability of streambed aggregates for concrete is therefore questionable and requires investigation. Rock is abundant, however, and quarries could be developed without much field study. Embankment materials should be plentiful along both banks and impervious core material can probably be found along the left bank near the site.

A contact between members of the Khorat Series probably occurs less than one kilometer northeast of the site. There the soil conditions have a lighter tone, the drainage pattern is different and the terrain is more flat with few knobs and hills. This change in conditions and terrain may mark the contact between the upper (Phu Pan) and the middle (Phra Wihan) members of the Khorat Series (or possibly between the middle and the lower (Phu Kadung) members. According to published reports the contacts within the Khorat Series are conformable, hence there should be little if any difference in the dip of the beds in each member. Considerable differences can be expected in the character of the sedimentary beds, however, but since this contact occurs a reasonable distance from the site it should have little if any affect upon foundation conditions there.

There may be beneficial effects upon reservoir conditions on account of this contact location in that the area north of the site and for some diatance west (upstream) is probably underlain by fine-grained, impervious materials. This favorable condition appears to extend upstream for at least ten kilometers.

Conclusions

From a geological standpoint this site appears feasible for the construction of a concrete dam, but this opinion will have to be established by field investigation and exploratory borings.

/Sand and Gravel

Sand and gravel aggregates for concrete may not be available for concrete construction in the vicinity of the site but rock is abundant, however, and a quarry could be developed for crushed rock.

No unusual problems or difficulties are envisioned which would affect design and construction. Exploration here can be conducted by a minimum number of borings, test pits or trenches.

Recommendations

A geologic map and a construction materials survey should be made for the site area.

A minimum of three borings should be made as a preliminary subsurface exploration program. One of these should be a vertical boring near the midpoint of the channel to determine overburden thickness and character of bedrock. The other two, one along the river line at each bank, should be inclined to intersect each other under the channel. These borings should be no smaller than NX diameter and water pressure tests should be made.

Two test pits should be made on each abutment slope to determine overburden thickness, followed by geophysical studies.

THAKHEK DAMSITE AREA

The Thakhek site is located approximately 15 kilometers northwest (upstream) of Nakhon Phanom on the Mekong River in northeast Thailand.

This area is characterized by flat lands bordering the banks and the river is quite wide. The banks are covered by brown river silt and sand and no exposures of rock were seen during the visit.

A long flat strip of land is under extensive cultivation on the Thailand side which extends over 3 kilometers upstream from the tentative dam axis. No outcrops were seen during the period of the visit.

The left bank (Laos side) was not visited but the air photographs show a series of low ridges and depressions trending parallel with the Mekong about one kilometer from the shore. This condition may be caused by tilting of the beds near the margin of the plateau but this opinion is conjectural and unconfirmed. To what extent the underlying sedimentary beds in the channel and on the Thailand

/side may

side may be similarly tilted cannot be surmised. The air photos do not show evidence of any kind. It therefore remains to visit this area during a low period of the Mekong to observe bank and channel conditions.

Based on published geologic data, the Thakhek area is underlain by Jurassic and younger sedimentary and metamorphic rocks, mainly sandstone and sandy shale. In this respect, the Thakhek site is different in being the only one investigated that is not underlain by the older Triassic beds of the Khorat Series. The Mekong flows through this belt of Jurassic rocks from as far north as Nong Khai and the gradient of the river is quite low between Bung Kan and Thakhek. To what extent these conditions may reflect the character of the underlying bedrock at the Thakhek damsite is not easily surmised, and can only be known by subsurface investigation. It is possible that the bedrock conditions here may be less satisfactory for foundation support than is the case in the Khorat beds at the other sites.

Conclusions

Geological conditions at the Thakhek site are uncertain due to a lack of bedrock exposures.

This situation will probably call for a greater amount of subsurface investigation than at the other sites.

It seems probable that the entire site area is underlain by a much softer grade of bedrock than is the case at the other sites.

The topographic conditions at the tentative axis location do not appear to be very satisfactory due to the wide channel and low, flat areas bordering both banks. Alternate axis locations do not appear possible upstream or downstream.

Recommendations

A second reconnaissance of the Thakhek area should be made during low water to observe bank and channel conditions and to select a favorable axis location, followed by geologic mapping and a construction materials survey.

/SUMMARY

SUMMARY

1. All of the sites investigated except Thakhek appear reasonably feasible for dam construction.

2. The Thakhek site may require a greater amount of exploration than the others in view of topographic features and uncertain geologic conditions.

3. Several tentative axes can be selected along the Mekong in the vicinity of the Upper and Lower Pakse and Khemarat sites where the geological conditions are considered to be similar to those described in this report.

4. An axis location in any given case can best be determined by a careful study of channel width to provide adequate spillway capacity, by consideration of bank and channel conditions during low water, and the topographic features which will affect river diversion and dam construction.

5. The critical location of the proposed Nam Mune Damsite near the confluence with the Mekong with respect to either the Upper or Lower Pakse sites presents a serious problem to the construction of any dam on the Mekong in the vicinity.

6. The very great size of any dam to be built on the Mekong coupled with extremely difficult channel diversion problems, unfavorable conditions for a side-channel spillway and navigation and other requirements would seem to favor the construction of a concrete gravity dam.

7. Geological conditions in general appear to be reasonably favorable for concrete gravity dam construction but much exploration will be necessary to clearly understand the foundation problems.

8. The construction of concrete dams of this magnitude involves a very great volume of coarse and fine aggregate. Sandstone is the predominant bedrock of the region but many beds are soft and weathered. Although some hard, firm beds are known to occur, their location, quality and volume available will require considerable prospecting in the vicinity of any given site. In some cases sand and gravel bars may supply fine and coarse aggregates but this possibility also bears careful investigation in the vicinity of each site.